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IBM Systems Reference Library

IBM 1800 Data Acquisition and Control System System Summary

This publication introduces system concepts, units, features, and programs for the 1800 System. This information will help the user achieve a basic understanding of the system and the interrelationship of its many parts.

Publications providing detailed information on the subjects described in this summary are listed in the IBM 1800 Data Acquisition and Control System Bibliography (Form A26-5921).

This publication supersedes and makes obsolete the
previous edition (Form A26-5920-0).

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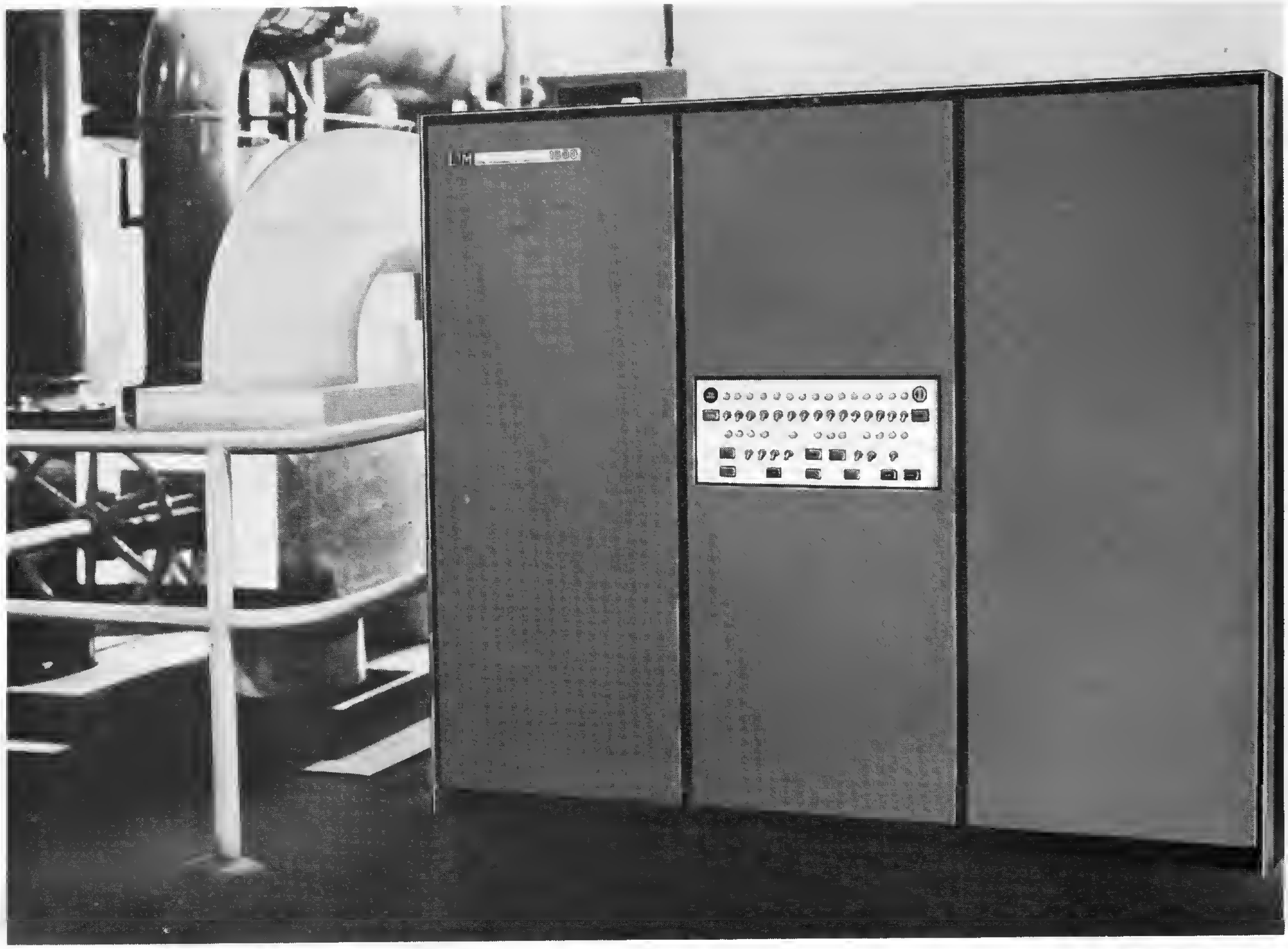


IBM 1800 Data Acquisition and Control System

The ever increasing pace of technology, industry, and business continues to demand more and more reliable, up to date information. History is a good teacher...true...but its compression within the past few decades of progress has taught us that today's problems require real-time answers, not a history of past performances. Data of almost every conceivable nature — available from a myriad of sources — must be collected, analyzed, and translated into terms that can be used to optimize today's performance.

IBM's answer to the demand for real-time data acquisition, analysis, and control is the IBM 1800. Here is a system designed to handle a wide variety of real-time applications, process control, and high-speed data acquisition. Each system is individually tailored with modular building blocks that are easily integrated to meet specific system requirements. The many advantages of Solid Logic Technology (SLT) with its micro-miniature electronic components are used. A large family of real-time process input/output (I/O) devices is included, such as analog input, analog output, contact sense, and contact operate; as well as data processing I/O units, such as magnetic tape, disk storage, line printer, graph plotter, card and paper tape input and output. Data are received and transmitted on either a high-speed Data Channel (cycle-steal) mode or under program control, depending on the intrinsic data rate of the I/O device. These capabilities not only meet today's requirements, but those of the future as well.

The 1800 includes a Processor-Controller (P-C) for editing, supervisory control, direct control, or data analysis. A control and data path provides for the attachment of the IBM System/360 where more powerful supervision is required. For example, the System/360 may be used to integrate the commercial aspects of an application with the controlling operations exercised by the 1800 system. This multiprocessor system's capability enables the handling of real-time applications of any size or complexity.

APPLICATIONS

The IBM 1800 is capable of accepting electrical signals, both analog and digital, from such devices as thermocouples, pressure and temperature transducers, flow meters, analytical instruments, and contacts. It provides electrical digital and analog control signals for the customer's controlling devices. Typical applications exist in the area of process control and high-speed data acquisition.

Process Control

System configurations for industrial processing applications include minimum systems that are field expandable to larger systems. Applications include petroleum refining, butadiene reactor control, chemical processing, electric utility dispatching and generation control, steel rolling, and many others. A complete range of process control, from off-line operator guidance through on-line supervisory control, may be exercised. Some of the degrees of control that an 1800 may exercise are:

1. Data Acquisition
2. Data Collection and Analysis
3. Data Evaluation and Operator Guidance
4. Process Study
5. Process Optimization
6. Supervisory Control

High-Speed Data Acquisition (HSDA)

High-Speed Data Acquisition includes the collection, evaluation, and recording of data. The 1800 collects data at analog rates up to 20,000 conversions per second per ADC and at digital rates up to 100,000 samples per second. Telemetry data can be acquired in bursts at rates up to 500,000 words (8,000,000 bits) per second. The 1800 provides flexibility of scanning rates and patterns by random or sequential multiplexer addressing during a test or experiment.

HSDA System operations range from the recording of data on magnetic tape or disk storage, with a minimum of editing and checking, to operations including data reduction and real-time display. Typical applications include:

1. Missile pre-launch and manufacturing checkout
2. Wind tunnels
3. Static test stands
4. Missile telemetry
5. Nuclear reactor research and testing
6. Environment chambers
7. Flight simulators
8. Low energy particle research
9. Medical research and clinical systems
10. Hybrid systems

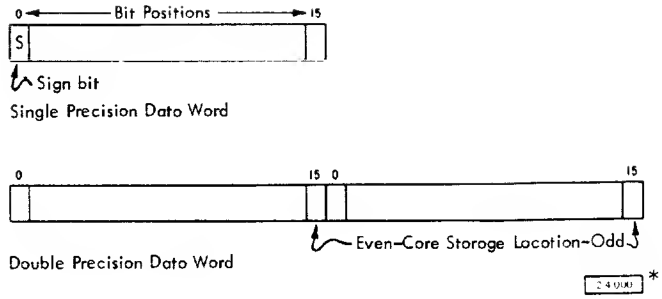
Other Acquisition and Control

The 1800 system may be applied to a diverse group of applications from general research to specific manufacturing tasks. Applications here include:

1. Research instrumentation and testing
2. Traffic control
3. Engine testing
4. Components manufacturing control
5. Automatic assembly and control
6. Component inspection and sorting
7. Automatic quality control

SYSTEM LANGUAGE

The 1800 system processes information in binary form for fast parallel manipulation of data. Data is stored and processed in fixed-length 16-bit words with provisions for addressing and processing of double-precision words (32 bits). Two additional bits are provided for parity and storage-protect purposes.



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The basic instructions and their numerous modifications are included in the following five classes:

1. Load and Store
2. Arithmetic and Logic
3. Shift
4. Branch
5. I/O

These instructions can be either one or two words in length depending upon the method of addressing.

*NOTE: The illustrations in this manual have a code number in the lower corner. This is a publishing control number and is unrelated to the subject matter.

PROCESSOR-CONTROLLER

Either the 1801 or 1802 Processor-Controller (Figure 1) can be used in the IBM 1800 System. The 1802 includes circuitry and control for connection and operation of the IBM 2401 and 2402 Magnetic Tape units as described in the "Data Processing I/O Units" section of this manual.

Each Processor-Controller is available in two models: the Model 1 has a core storage cycle of four microseconds; the Model 2 core storage cycle is two microseconds.

Both models are available with four core storage capacities: 4K (4096 words), 8K (8192 words), 16K (16,384 words), or 32K (32,768 words).

The following six features are standard on all Processor-Controllers:

Data Channel. The high-speed input/output channel enables asynchronous I/O unit operations. In these operations the use of core storage to read or store data affects the main program execution only by a cycle delay per word (an operation called "cycle stealing"). The feature enables burst-mode input/output operations at rates up to 500,000 words (8,000,000 bits) per second with the 2-microsecond core storage. Three Data Channels are provided; six additional Data Channels are available as special features.

Index Registers. Three index registers provide a means of saving program steps, core storage, and computer processing time. Indexing an instruction causes the contents of an index register to be added to the instruction address to form the desired effective address for that instruction. The 1800 instruction set includes instructions to load, store, and modify index registers.

Indirect Addressing. Indirect addressing causes the address portion of the instruction (plus the contents of an index register, if specified) to be used to indicate the location of the effective address.

Interval Timers. Three interval timers are provided to supply real-time information to the program. Each timer has one permanent time base which can be selected from the following time base periods: 0.125 milliseconds (Model 2 Processor-Controllers only) and 0.25, 0.5, 1, 2, 4, 8, and 16 milliseconds.

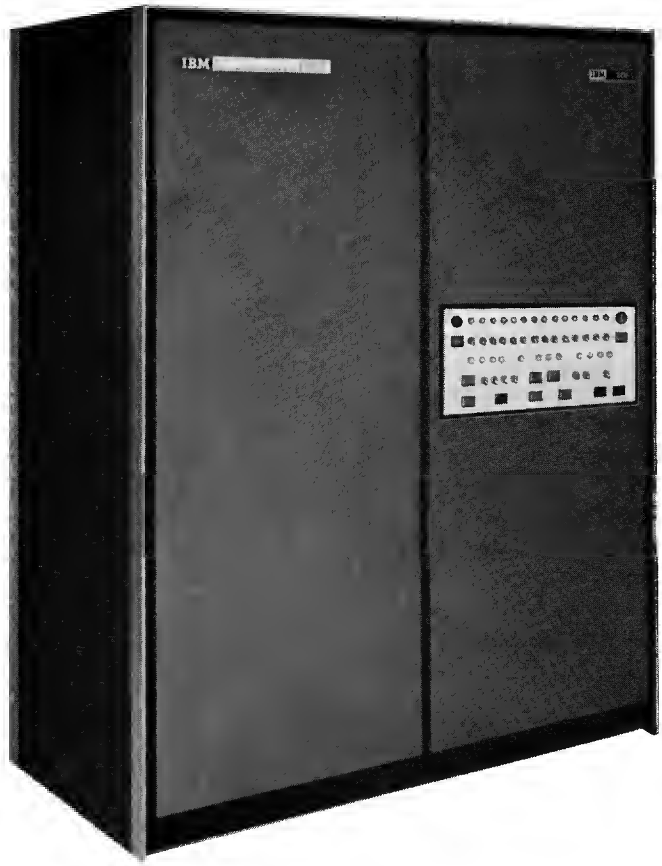

Figure 1. 1801 or 1802 Processor-Controller

Operation Monitor. This feature provides a means of sounding an alarm or setting an indicator upon completion of a preset timeout period.

Interrupt. The interrupt facility provides an automatic branch in the normal program sequence based upon external conditions. Some typical interrupt conditions are: the interval timer reaching a preset time interval, an I/O device being ready to transfer data, an illegal operation code, or an external process condition that needs attention. Interrupt conditions are assigned levels according to the customer's requirements. Twelve levels of interrupt are provided and twelve additional levels (2 groups of 6 each) are available as special features.

Parity and Storage Protect. The core storage array provides 18 bits per word. Sixteen are used for

data. One bit can be used to indicate that the word is "read only." This provides flexible storage protection against the erroneous storing of information in a protected area during program execution or input/output operations on a Data Channel. The remaining bit provides odd parity on the other seventeen bits. Detection of a parity check or attempted violation of storage protection causes an interrupt to the highest priority level.

PROCESS I/O UNITS AND FEATURES

Analog Input

The collection of analog data and its conversion for presentation to the digital Processor-Controller is the function of the Analog Input feature.

A physical phenomenon is first sensed and converted to an analog electrical signal by sensors or transducers, such as thermocouples or strain gages. All customer lines from transducers are terminated at the control system on screw-down terminals. The signals are also conditioned at the terminals, including the filtering of extraneous signals, known as noise. Electrical signals from sensors or transducers may be in the millivolt, volt, or milliampere range. Low voltage signals (less than 1 volt) must be amplified to a level acceptable for conversion to digital form.

The amplification factor by which low-level signals are multiplied to reach the acceptable high level is termed the "gain" of the amplifier.

Conversion of analog signals from a voltage level to digital information is accomplished by an Analog-to-Digital Converter (ADC). Such converters, however, are complex enough so that if multiple sources of analog signals are to be converted, they share the use of one ADC. The switching of analog signals is accomplished by a multiplexer. The data path from sensor or transducer to processor is shown by Figure 2. The analog input units and features consisting of modular packaged equipment convert voltage or current signals into digital values. The modules used to accomplish the conversions include analog-to-digital converters, multiplexers, amplifiers, and other signal-matching elements.

Customer input signals are routed through terminals, signal conditioning elements, multiplexer switches, a time-shared amplifier, and into the analog-digital converter (ADC). The output of the ADC is presented to the Processor-Controller (P-C) via programmed I/O control or the Data Channel from an ADC output register.

The major features that accomplish the analog input function are briefly introduced below. More detailed descriptions are given in the IBM Systems Reference Library Publication, IBM 1800 System Reference Manual (Form A26-5918). Figure 3 illustrates the interrelationship of each of the features. There are two models of the Multiplexer Terminal. The Model 1 provides for the insertion of up to 64 multiplexer points in groups of 16 points. Customer wires are terminated on screw-down terminals. Four signal matching elements (filter, current, voltage and universal) are available for each multiplexer point used. These are also mounted in the Multiplexer Terminal. Up to two Differential Amplifiers can also be mounted in each terminal.

The Model 2 is modified to allow for thermal measurement of the terminals. Thus, thermocouple wires can be directly connected to the terminals and the cold-junction temperature can be read by the P-C. The maximum capacity of the Model 2 is 62 multiplexer points.

All other functions of the Model 2 Terminal are the same as the Model 1 Terminal. Thus non-thermocouple signals may also be terminated in the Model 2.

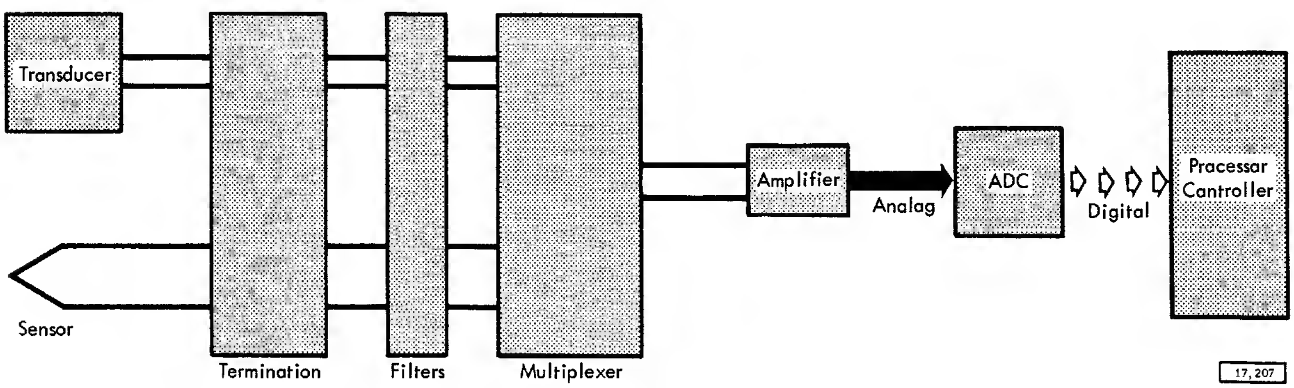

Figure 2. Data Path from Signal Source to P-C

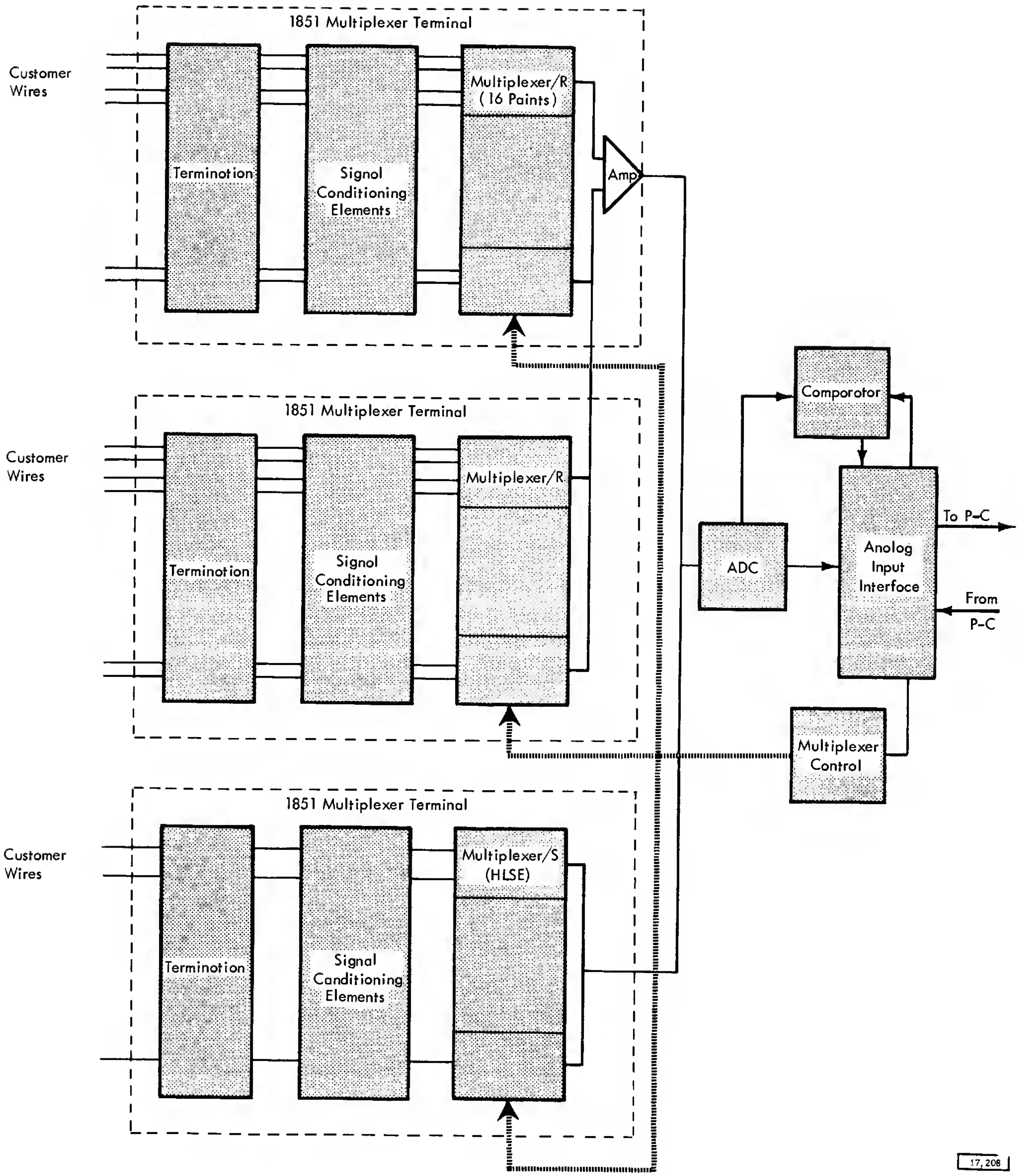

Figure 3. Schematic of Analog Input Features

1854 Hybrid Input Terminal. This feature provides the 1800 with the facility for terminating ±100 volt customer inputs. Up to 8 groups of 8 each can be terminated in the 1854. The 1854 can be mounted in an 1828 Model 2 and provides screwdown terminations on the back panel for customer wiring. A maximum of two 1854's can be installed with any ADC. One group of eight points is standard in the 1854.

Hybrid Input Matching Points. This feature provides attenuation of 20 to 1. Eight points are provided with each plug-in module. Up to seven groups of Hybrid Input Matching Points may be installed in an 1854. Thus, an 1854 can handle up to 64 points.

Multiplexer/R. This feature provides relay (R) multiplexing with high input impedance (greater than ten megohms), high common-mode voltage operation (200 volts) and high common-mode rejection. High- and low-level analog inputs are switched at a maximum speed of 100 points per second. The equipment is card mounted and plugs into the Multiplexer Terminal in groups of 16. For low-level signals, up to 16 groups can be combined to form the input to one time-shared amplifier providing up to 256 input points per amplifier. Each amplifier has fixed gain, and the full-scale input range for any group of Multiplexer/R points is dependent on the gain of the amplifier to which it is connected. Gains available are: 500, 250, 100, 50, 25, and 10. High-level inputs (-0.5 to 5 volts) do not require an amplifier. Up to 256 high-level points can be included on any ADC in the system.

The Multiplexer Overlap feature allows overlapping of switching times for the Multiplexer/R and Multiplexer/S points.

The maximum 100-point per second multiplexing rate applies randomly while 50-point per second applies as a repetition rate on any one point.

Multiplexer/S. This feature provides for solid-state multiplexing of high-level single-ended analog inputs at a maximum switching rate of 100 kc. System speeds are dependent upon the ADC, amplifier, etc. used in any particular system. The Multiplexer Overlap feature allows the overlapping of Multiplexer/R and Multiplexer/S within any single-ADC system. Groups of Multiplexer/S are mounted in the Multiplexer Terminal Model 1 and can not be intermixed with Multiplexer/R points within a terminal.

The input voltage range is 0 to ±5 volts full scale, and the multiplexer settles to ±0.01% of full scale in 5 microseconds.

Multiplexer Control/R and Additional Multiplexer Control/R. These features provide the necessary control circuitry to operate the Multiplexer/R points. Each feature can control up to 256 points.

Multiplexer Control/S. Control circuitry to operate the Multiplexer/S points is provided by this feature.

Multiplexer Overlap. This feature allows the operations of Multiplexer/R and Multiplexer/S to be overlapped. (Note: overlap of Multiplexer/R operations with other operations for Multiplexer/R is not possible.) There are three possibilities by which overlapping occurs. All three can be operative independently or at the same time.

1. Under programmed control, solid state conversions can be performed while a relay point is being selected.
2. If a discrete conversion of a relay point is started under programmed control, a sequence of conversions of solid-state points can be started on Data Channels.
3. Under two Data Channel operations, overlapping is also possible. Relay addresses can be inserted in the data table of multiplexer addresses.

Signal Conditioning Elements. Four signal conditioning features are available:

1. Current Element. Four to 20-milliamp current input signals are converted into either 0.1 to 0.5 volt or 1 to 5 volt input signals.
2. Filter Element. A low-pass passive filter to reject common-mode and normal-mode AC noise. (For Multiplexer/R only).
3. Voltage Element. Provides 2:1 voltage attenuation. For example: 100 millivolt signals may be read as 50 millivolt signals.
4. Universal Element. A mounting facility which accommodates the voltage or filter elements or allows custom signal conditioning for current, filter, voltage, and bridge capabilities. The components that perform the customized function are provided by RPQ* or the customer.

Differential Amplifier. This feature is a time-shared amplifier that is used in conjunction with the Multiplexer/R to raise analog signals to the ADC input level of ±5 volts.

*Request Price Quotation from IBM

Any one gain setting selected from 500, 250, 100, 50, 25 and 10 can be specified. These allow input voltage ranges on the connected Multiplexer/R points to be: ±10, ±20, ±50, ±100, ±200, and ±500 millivolts.

Up to two amplifiers can be mounted in one Multiplexer Terminal. Thus, multiple amplifiers can be used for voltage-range changing in place of using passive voltage elements.

Analog-to-Digital Converter (ADC). The feature provides the 1800 with the ability to convert bipolar analog signals (±5-volt signal range) to digital values. Two ADCs are available: Model 1 includes a buffer amplifier and has program selectable resolutions of 8, 11, and 14 bits. Model 2 is similar to the Model 1 except that it includes a sample and hold amplifier which provides for an increased system speed of conversion.

The ADC conversion time is dependent only upon the number of bits of output that are to be developed. Conversion times are as follows: 8 bits, 29 microseconds; 11 bits, 36 microseconds; and 14 bits, 44 microseconds. Therefore, actual ADC conversion rates vary from 35,000 conversions per second to 23,000 conversions per second. (This does not include settling time for the amplifier within the ADC.)

System conversion rates vary from 9000 to 25,000 samples per second.

Comparator. This feature performs selective checking on the digital values converted by the ADC. A range-type check is made to confirm that the converted values are within specified limits. The limits are obtained from the Multiplexer Address Data Table whenever a check is required (one P-C cycle delay allows both limits to be acquired). The P-C is informed of an out-of-limits condition by an interrupt.

Analog Input Data Channel Adapter — 1. Allows chained sequential mode of analog input operation by connecting a Data Channel to the analog input interface.

Analog Input Data Channel Adapter — 2. Allows Random mode of analog input operation by connecting a second Data Channel to the analog input interface.

Analog Input Expander. This feature provides two principal advantages:

1. It doubles the capacity of the analog input features.
2. It allows the analog input features to be located separate from the Processor-Controller.

The Analog Input Expander provides the basic capability for attachment of an ADC, a Comparator, the Multiplexer Terminals, etc. This second analog input system attaches to I/O Control and Data Channels in a similar manner to the first analog input system. Thus, the system conversion rates can be doubled, neglecting I/O interaction.

Performance: The analog input system performance specifications are as follows:

Accuracy (relay)	±0.1% of F.S. ±1/2 LSB*
Repeatability (relay)	±0.06% of F.S. ±1/2 LSB
Accuracy (solid state)	±0.06% of F.S. ±1/2 LSB
Common-mode rejection	1,500,000 to 1

The above figures do not include temperature coefficient or long term drift and are based on environment of 77°F ±5°F.

Digital Input

These features enable the Processor-Controller of the system to accept real-time digital information in a digital format.

Digital input is brought into the system in 16-bit groups. The format may be in any form. For example: (1) unrelated bits from contact or voltage levels, (2) related bits such as binary-coded-decimal digits. Any mixture of digital formats can be handled. Conversion from one base to another can be easily and quickly implemented by programming. Input is via program control or a Data Channel. One instruction is used in program control to bring 16 bits of data into core storage. Where a Data Channel is used, one instruction initiates a cycle-stealing operation that brings many 16-bit groups of data into core storage, (one group per memory cycle). The number of groups read — sequentially, randomly, or singly — as well as synchronization of the input data to the Processor-Controller is handled automatically.

The following seven features, along with prerequisite features implement the 1800 Digital Input capabilities. (See IBM 1800 Configurator, Form A26-5919.)

Digital Input (Contact). Input groups of 16 bits are available, up to a total of 64 groups. Read speed rates of up to 500,000 words (8,000,000 bits) per second in burst mode are possible when the Data Channel feature is present on a system with 2 μsec memory.

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*F.S. is Full Scale; LSB is Least Significant Bit. Full scale for relays is 50 millivolts and for solid state is 5 volts.

Digital Input (Voltage). Sensing and termination are provided for groups of 16 voltage-level source inputs, up to a total of 64 groups of 16 bits each. The voltage levels are:

Binary One: — 1 v min. to +30 v max.

Binary Zero: —6 v min. to —30 v max.

Read speed rates up to 500,000 words (8,000,000 bits) per second in burst mode are possible. Digital registers, including telemetry registers, are coupled to the system using one or more modified voltage-level groups, depending on register size and the number coding of the register. Conversion of the various number bases is accomplished via programming. Speeds up to a repetitive rate of 100,000 words (1,600,000 bits) per second can be handled.

Digital Input Channel. Process Operator Console (POC) input devices such as decade switches and sense switches and other low-speed inputs can be brought into the system by the formation of a "Digital Input Channel" using Electronic Contact Operate to select various groups of 16 bits over a single digital input group. POC input devices and cabling are handled via RPQ.

Pulse Counter. This feature accepts discrete pulses as input information and advances by one per received pulse. The customer pulse rate should not exceed 5 kc (5,000 cycles per second) unless RPQ filters are used. These counters can be read into the P-C in the same manner as the digital input group. The basic counter is an 8-bit binary counter. Two counters are read in per word from one address and can be factory coupled together to obtain a 16-bit binary counter. The counters are reset on read out. A maximum of 128 counters are available in any one system. Voltage levels are the same as those for Digital Input (Voltage).

Process Interrupt (Contact). This feature provides termination and sensing of 16 customer contacts per group, maximum of 24 groups. (See Interrupt feature.)

Process Interrupt (Voltage). This feature provides termination and sensing of 16 customer voltage levels per group, maximum of 24 groups total (contact and voltage).

Interrupt is initiated by a contact closing, or a voltage level changing from "0" to "1". Process conditions may interrupt the P-C on a multilevel priority basis (see Interrupt Feature).

Digital and Analog Output

The Digital and Analog Output (DAO) features provide versatile control capability for the 1800 System. DAO features permit the exercising of computer control over the many types of auxiliary devices required in a control system. Equipment that can be controlled includes set-point positioners, actuators, displays, and telemetry systems. The control outputs available with the DAO include the following:

1. Pulse Output
2. Electronic "Contact" Operate
3. High-Speed Digital Register Output
4. High-Speed Analog Voltage Output

Digital Output

Digital Output features are attached to the P-C through the Digital Output Control and the Digital Output Adapter. Output is in groups of 16 bits. Each Adapter connects 64 bits of digital output, and each Digital Output Control (8 per system) provides for four (4) Adapters. Thus the system capacity for digital output may be as high as 2048 points (128 groups of 16 points). This limit is modified if Analog Output is installed (see Analog Output).

Pulse Output. The electrical output of the Pulse Output feature has the characteristics required to operate set-point positioners and stepping motors. Solid-state circuitry provides a 3 millisecond, 48 volt dc pulse. Sixteen points may be set simultaneously by an XIO (Execute I/O) instruction. A data bit of "1" causes an output pulse, and a data bit of "0" causes no pulse.

Electronic Contact Operate. This latching-switching function is provided by a solid-state device requiring only 10 microseconds (μsec) to latch, and 10 more μsec to unlatch. The rating of the switching device is 450 milliamperes (ma) at 48 volts dc. Sixteen points are latched simultaneously. The switching commands are identical to those for pulse output, with a data bit of "1" causing a latch. This switching action operates alarms, console indicator lights and other displays, and operating process equipment such as relays, conveyor belts, and pumps.

Register Output. Digital output information is transferred from core storage (16 bits per transfer) to an output register. With this type of digital output, the entire 16 bits may be simultaneously transferred to another register which is part of an external device, such as a telemetry system. The feature may be used with a Data Channel to transfer repetitively to a single register or to several registers on a cycle stealing basis. An external sync signal may be used to initiate the transfer.

The maximum data rate if 500,000 words per second, 16 bits per word. The electrical characteristics of the signal provide 32 milliamperes of current, including termination and customer load, supplied at +3 volts.

Analog Output

The Analog Output features are connected to the 1800 System through an 1856 Analog Output Terminal. A total of sixteen 1856 Analog Output Terminals may be used in a system. System capacity is 128 analog output points (64 Digital-Analog Converters — DAC). Note that one DAC is equivalent to a 16-point digital-output group and that the system limit of 128 groups of digital and analog output must be observed. To provide the most flexible capacity expansion, the analog output points may be added in groups of one or two points.

1856 Analog Output Terminal. There are two models of this unit:

- Model 1 — Provides power and housing for 8 points of analog output (any model of DAC) and control for 16 points of analog output. The Model 1 is repeated for each multiple of 16 points required.
- Model 2 — Provides power and housing for eight points of analog output (any model of DAC). One Model 2 can be installed for each Model 1, if the additional points are required.

There is a maximum of sixteen 1856s per system (counting both models).

Digital-To-Analog Converter (DAC). There are four models of this feature.

- DAC Model 1 — Provides digital-to-analog 10-bit conversion for one analog output point.
- DAC Model 2 — Provides 10-bit conversion for two analog output points.
- DAC Model 3 — Provides 13-bit conversion for one analog output point.
- DAC Model 4 — Provides 13-bit conversion for two analog output points.

The DAC's Precision Voltage Reference feature or a customer voltage reference that meets the requirements of the DACs must be used to obtain analog output voltages from the above.

Buffer Register (DAC Models 3 and 4 Only). When the Buffer Register feature is added to the 13-bit DAC, an additional signal is required to load broadside the output DAC registers from the buffer registers. The buffer registers (one per point) are loaded as the data is received from the Processor-Controller. When the program has loaded all of the specified buffer registers, an I/O control command is given; bit nine in this command is the signal that loads the DAC registers.

Precision Voltage Reference (PVR). This feature provides a precision voltage reference for use with the DAC. One PVR serves 8 points of analog output. There are two models:

- PVR Model 1 — Provides a +20-volt reference for DACs converting from 10-bit input.
- PVR Model 2 — Provides a ±20-volt reference for DACs converting 10-bit or 13-bit input.

For example, a 10-bit point can be installed in the 1856 Analog Output Terminal with other 13-bit points and the available PVR Model 2 reference can be used with the 10-bit point. Maximum is 16 per system.

Analog Driver Amplifier. The output impedance of the Digital-To-Analog Converters is 10,000 ohms. When it is desired to match loads differing greatly from this value, an Analog Driver Amplifier having an output impedance of less than one ohm may be used. This driver amplifier is applied on an individual point basis to provide load impedance matching and voltage amplification. The driver amplifier will also be used when it is desired to increase the analog output voltage from its nominal 5 volts to 10 volts.

DATA PROCESSING I/O UNITS

The following IBM units are available for attachment to the 1800 system.

IBM 1816 Printer-Keyboard (two)*

The 1816 (Figure 4) provides typewriter output at a maximum rate of 14.8 characters per second and provides for data entry into the Processor-Controller via a keyboard.

IBM 1053 Printer (eight)

The 1053 (Figure 5) provides typewriter output at a maximum rate of 14.8 characters per second. When multiple 1053s are installed they can simultaneously print independent messages from the Processor-Controller.

IBM 1442 Card Read Punch (two)

The 1442 (Figure 6) provides serial reading and punching of cards. Two models are available for attachment to the 1800.

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*This number indicates the maximum number of units that can be installed on an IBM 1800 system.

Figure 4. 1816 Printer-Keyboard

Figure 5. 1053 Printer

Model 6 — 300 cards per minute read
80 columns per second punch
Model 7 — 400 cards per minute read
160 columns per second punch

IBM 1443 Printer (two)

The 1443 Printer (Figure 7) is buffered and operates on a Data Channel to provide on-line printing with a minimum amount of Processor-Controller time and attention. Two models are available. Printing speeds range from 120 to 600 lines per minute depending on the model and the character-set.

IBM 1054 Paper Tape Reader (one)

The 1054 Paper Tape Reader (Figure 8) reads one-inch eight-track paper tape at a maximum rate of 14.8 characters per second. Data is read into the Processor-Controller core storage as an image of the holes in the tape, with each punched character being read into one addressed core storage location. Code translation must be done by programming to determine the characters in core storage.

IBM 1055 Paper Tape Punch (one)

The 1055 Paper Tape Punch (Figure 9) punches one-inch eight-track paper tape at a maximum punching rate of 14.8 characters per second. Data is punched as an image of the data in core storage on a character-to-character basis.

Figure 6. 1442 Card Read Punch

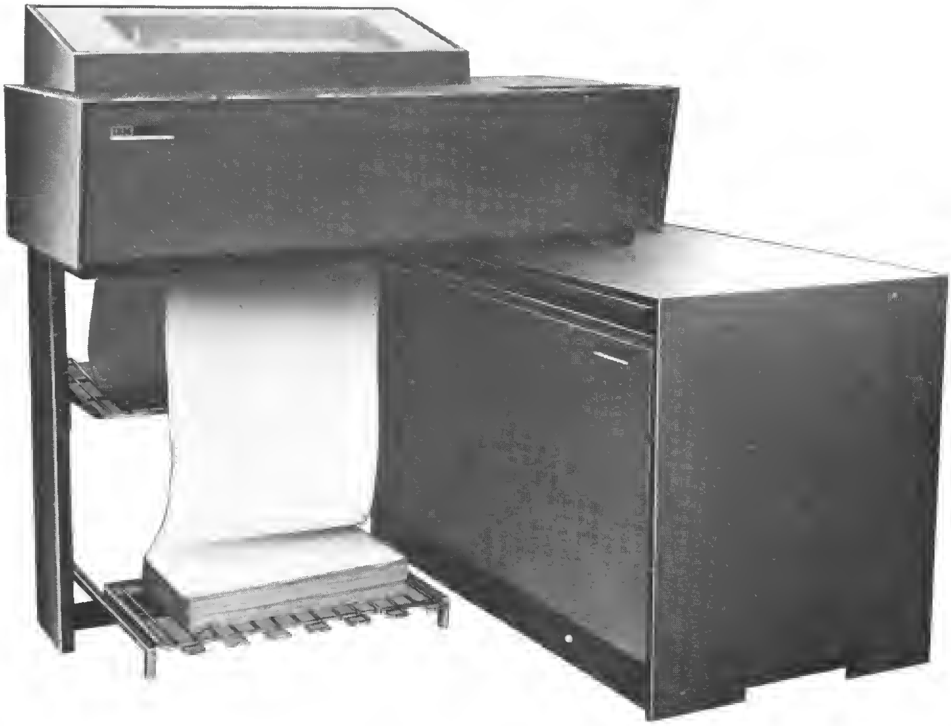

Figure 7. 1443 Printer

Figure 8. 1054 Paper Tape Reader

Figure 9. 1055 Paper Tape Punch

Figure 10. 1627 Plotter

IBM 1627 Plotter (two)

Models 1 and 2 of this incremental plotter (Figure 10) are available on the 1800 to create digital information in any desired graphical form. The plotter operates at 200 or 300 steps per second depending upon the model.

IBM 2401/2402 Magnetic Tape Units (two/one)

The 1802 Processor-Controller includes tape control circuitry for the connection of IBM magnetic tape units to the 1800 system via a Data Channel. A maximum of two tape drives can be attached to an 1802. The following IBM magnetic tape units are attachable:

2401 — single 9-track tape unit (Figure 11)
Model 1 - 22.5 kc
Model 2 - 45 kc
Model 3 - 90 kc

2402 — double 9-track tape unit (Figure 12)
Model 1 - 22.5 kc
Model 2 - 45 kc
Model 3 - 90 kc

The Seven-Track Read-Write Head feature for 2400 series tape units is available for the 1800 system.

IBM 2310 Disk Storage (one)

The 2310 Disk Storage is a storage device with both random and sequential access capabilities. Its storage medium is an oxide-coated disk in an interchangeable cartridge. A magnetic head for each surface performs reading and writing functions. There are 200 "cylinders" of two tracks each, providing a storage capacity of 512,000 16-bit words. The 2310 operates on a Data Channel with a reading/writing rate of 35,000 words per second (700,000 bits per second).

The 2310 Model A1 contains one disk storage drive; Models A2 and A3 contain two and three disk storage drives respectively.

Figure 11. 2401 Magnetic Tape Unit

Figure 12. 2402 Magnetic Tape Unit

SYSTEM ENVIRONMENT

System units are designed to operate within the following temperature and relative humidity ranges:

Machine	Temperature	Relative Humidity*
1801, 1802, 1826, 1828 1851, 1854, 1856	40 - 122°F	8 - 95%
1053, 1054, 1055, 1816	50 - 110°F	10 - 80%
1442, 1443, 2401, 2402, 1627	60 - 90°F	20 - 80%
2310	50 - 105°F	10 - 80%

*Maximum wet bulb is 85°F.

IBM provides 1800 system users with a powerful set of programs and programming systems. They are specifically designed to relieve the user of much detailed programming effort. This section presents a brief description of each program. Publications supplying detailed information on each program are listed in IBM 1800 Bibliography (Form A26-5921).

Machine Requirements

The minimum machine configuration required for use of any program described in this section includes:

1. IBM 1801 or 1802 Processor-Controller with a minimum of 4096 words of core storage.
2. IBM 1054 Paper Tape Reader and an IBM 1055 Paper Tape Punch, or an IBM 1442 Card Read Punch.

In addition to thc machine units listed above certain programs require other units. The additional units required are listed with the program description.

ASSEMBLER

The 1800 System Assembler language permits the programmer to write (code) source programs in a symbolic language that is more meaningful and easier to use than the binary machine language. The symbolic language provides the programmer with mnemonic operation codes, special characters, and other necessary symbols. The use of symbolic labels (names) makes a program independent of actual machine locations. Unique mnemonic operation codes are included which relieve the programmer of coding the machine-language instruction modifications.

Macro-instructions are included which (in conjunction with the program loaders) automatically provide linkage to the IBM supplied subroutines. The subroutines provided are listed in the Subroutine Library which is described later. Macro-instructions may also be added for communication with customer provided subroutines.

The source program, punched in either cards or paper tape, is assembled into machine language by the 1800 Assembler. The object program is punched into the first 20 columns of the source card (by the card assembler) during the second pass of the two-pass assembler. This deck is termed the "list deck." The paper tape assembler punches the object program during the second pass of the source program.

Before the object program can be loaded into the Processor-Controller for execution, it must be acted upon by the Compressor Program. This program "compresses" the object information from several list-deck cards into one card. This deck, known as the Compressed Binary Object Program deck, can be loaded with the Relocatable Loader or it can be converted into core-image format by the Core-image Converter Program. The core-image format deck can be loaded by the Core-image Loader.

Either the Relocating Loader or the Core-image Converter Program will select (and supply the necessary linkage for) the subroutines used by the object program.

FORTRAN

FORTRAN (FORmula TRANslation) is a programming language that allows the engineer and scientist to utilize a computer for problem solving with only a slight knowledge of the computer and a relatively short period of training. FORTRAN is a language that is a compromise between the language of the computer and the language of the scientist and engineer. To satisfy the computer, FORTRAN statements are converted to machine language. To satisfy the engineer and scientist, as many of the detailed computer control operations as possible are eliminated from the job of writing programs, and a statement format close to that of the mathematical equation is used.

The source program, once it is punched into cards or paper tape, is compiled into an object program by the FORTRAN Compiler Program.

The object program can be loaded to core storage for execution by the Relocating Loader, or it can be changed to core-image format by the Core-image Converter Program and loaded to core storage by the Core-image Loader. The Relocating Loader or the Core-image Converter Program will select and automatically produce the linkage for the subroutines required by the object program.

Additional Machine Requirements

In addition to the machine requirements previously listed for 1800 system programs, one of the following units is required to compile FORTRAN

programs:

IBM 1053 Printer
IBM 1443 Printer
IBM 1816 Printer-Keyboard

SUBROUTINE LIBRARY

The subroutines for the 1800 system are a package of commonly used routines for data input/output, data conversion, and arithmetic functions. The subroutines required for operation of an object program are selected by the Relocating Loader or Core-image Converter Program when the object program is being processed.

The subroutines included in the Library Subroutine group are:

Input/Output

Card
Disk
Printer (1443)
Keyboard/Console Printer
Console Printer (1053)
Magnetic Tape
Paper Tape
Plotter (1627)
Analog Input
Digital Input
Analog/Digital Output

Functional Subroutines

Trigonometric Sine/Cosine
Trigonometric Arctangent
Square Root
Logarithm (natural)
Exponential

Arithmetic

This group includes 30 subroutines designed to augment the Processor-Controller arithmetic instructions. The subroutines perform such functions as floating-point single-word and double-word precision for Add, Subtract, Multiply, Divide, etc. Only the subroutines required for operation of the object program are loaded to core storage during execution.

Conversion

This group includes eleven data conversion subroutines to be used to convert data from and to the various input/output codes of the I/O devices that can be attached to the system.

Additional Machine Requirements

In addition to the machine requirements previously listed for the 1800 programs, one or more of the following units may be required for operation of the supporting subroutine. (For example, the Plotter Subroutine requires that the IBM 1627 Plotter be attached to the 1800 system.)

IBM 1053 Printer
IBM 1443 Printer
IBM 1816 Printer-Keyboard
IBM 2310 Disk Storage
IBM 2401/2402 Magnetic Tape Unit
IBM 1627 Plotter
Analog Input
Digital Input
Analog/Digital Output

UTILITY ROUTINES

The Utility Routines supplied for the 1800 system comprise the following:

Input/Output routine
Dump routines
Console routine
Load routines

The Input/output routine performs the function of transferring information from one medium to another or to combinations of others. Input is accepted from cards, paper tape, or magnetic tape. Output can be to typewriter, printer, paper tape, magnetic tape, or card.

The Dump routines are used to output all or part of core memory to an output device, namely: card punch, typewriter, magnetic tape, or the printer. Any area of memory may be dumped; however, the first 300 words of memory contain the dump routine itself. The output can be in either decimal or hexadecimal form.

The Console routine is a program testing aid which allows dumping of selected portions of memory. This routine is contained in one card and requires only 80 words of memory. All output is in hexadecimal form on the typewriter.

The Loading routines are used to load the output of the Symbolic Assembler or the FORTRAN compiler. The Relocating Loader accepts output directly from the assembler or compiler and loads the object program and the required subroutines to core storage for program execution.

The assembler or compiler output must be acted upon by the Core-image Converter Program before the object program can be loaded by the Core-image Loader.

Additional Machine Requirements

In addition to the machine requirements previously listed for the 1800 system programs, one of the following units is required for operation of the Utility Routines:

IBM 1053 Printer
IBM 1443 Printer
IBM 1816 Printer-Keyboard

MONITOR SYSTEM

The IBM 1800-2310 Monitor System is a disk-oriented program that allows the user to assemble, compile, and/or execute individual or a group of programs with a minimum of operation intervention. Jobs to be performed are stacked and separated by control records that identify the operation to be performed. The Monitor system provides programming flexibility for the diverse applications of real-time process control and data acquisition.

The Monitor System is comprised of five distinct but interdependent programs:

- Supervisor Program
- Disk Utility Program
- Assembler Program
- FORTRAN Compiler
- Subroutine Library

The Supervisor program provides the necessary control for the stacked-job concept. In other words, it reads and analyzes the control records, and transfers control to the proper program.

The Disk Utility Program is a group of routines designed to assist the user in storing information (data and programs) on the disk and retrieving and using the information stored.

The Assembler Program converts user-written symbolic-language source programs into actual machine-language object programs.

The FORTRAN Compiler converts user-written FORTRAN-language source programs into actual machine-language object programs.

The Subroutine Library contains pre-written subroutines for data input/output, data conversion, and arithmetic functions.

The Monitor System coordinates the Processor-Controller activity by establishing a common communications area in memory which is used by the various programs that make up the Monitor System. It also guides the transfer of control between the various Monitor programs and user's programs. Operation is continuous and setup time is reduced to a minimum, thereby effecting a substantial time saving in processor-controller operation and allowing greater programming flexibility.

Machine Requirements

In addition to the machine requirements previously listed for the 1800 system programs, the following units are required for operation of the Monitor System.

1. IBM 1053 Printer, or IBM 1443 Printer, or IBM 1816 Printer-Keyboard.
2. IBM 2310 Disk Storage

TIME-SHARING EXECUTIVE SYSTEM

The IBM 1800 Time-Sharing Executive System is a real-time process-control monitor programming system that affords the user an easy means of generating, testing, and executing a complete process control program.

With this system, the user can:

- Write process control programs in the FORTRAN language or the 1800 system symbolic language.
- Execute both process control programs, and non-process control programs, concurrently.
- Call Executive programs (supplied by IBM) which aid in the control of various process functions.
- Simulate process interrupts and analog input/output to enable testing of programs, without using the physical process or the analog feature.
- Designate programs to be memory protected (in core or on disk) by programming.

MACHINE REQUIREMENTS

The machine units required for operation of the Time-Sharing Executive System are:

1. IBM 1801 or 1802 Processor-Controller,with a minimum of 8192 words of core storage.
2. IBM 1816 Printer-Keyboard
3. IBM 2310 Disk Storage
4. IBM 1054 Paper Tape Reader and an IBM 1055 Paper Tape Punch, or an IBM 1442 Card Read Punch.

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